CLAIMS

[1] A signal separation method that separates and extracts signals under conditions where N ($N \geq 2$) signals are mixed together and observed with M sensors, comprising:

a procedure that transforms the observed signal values observed by said sensors into frequency-domain signal values,

a procedure that uses said frequency-domain signal values to calculate at each frequency the relative values of the observed values between said sensors (including mapping these relative values),

a procedure that clusters said relative values into N clusters,

a procedure that calculates a representative value for each of said clusters,

a procedure that uses said representative values to generate a mask for the purpose of extracting, from said frequency-domain signal values, mixed signal values comprising the signals emitted from V ($2 \leq V \leq M$) signal sources,

a procedure that uses said mask to extract said mixed signal values from said frequency-domain signal values, and

a procedure that separates and extracts the values of V signals from said mixed signal values.

[2] A signal separation method according to Claim 1,

wherein said mask is a function that takes a high level value for said relative values that are within a prescribed range that includes V said representative values, and takes a low level value for said representative values that are not inside said prescribed range,

and wherein the procedure that uses said mask to extract said mixed signal values from said frequency-domain signal values is a procedure in which said frequency-domain signal values are multiplied by said mask.

[3] A signal separation method according to Claim 1,

wherein said mask is a function that takes a low level value for said relative values that are within a prescribed range that includes V said representative values, and takes a high level value for said representative values that are not inside said prescribed range,

and wherein the procedure that uses said mask to extract said mixed signal values from said frequency-domain signal values is a procedure in which the values obtained by multiplying said frequency-domain signal values by said mask are subtracted from said frequency-domain signal values.

[4] A signal separation method according to Claim 2,

wherein said mask is a function that the transitions from said high level value to said low level value that accompany changes of said relative value occur in a continuous fashion.

[5] A signal separation method according to Claim 1,

wherein the procedure that uses said representative values to generate a mask for the purpose of extracting, from said frequency-domain signal values, mixed signal values comprising the signals emitted from V ($2 \le V \le M$) signal sources is a procedure whereby said mask is generated by using the directional characteristics of a null beamformer (NBF).

[6] A signal separation method according to Claim 1, wherein the procedure that uses said representative values to generate a mask for the purpose of extracting, from said frequency-domain signal values, mixed signal values comprising the signals emitted from V ($2 \le V \le M$) signal sources includes:

a procedure that generates an $(N-V+1)\times(N-V+1)$ delay matrix $H_{NBF}(f)$ in which the element at (j,i) is equal to $\exp(j2\pi f\tau_{ji})$, where $\tau_{ji}=(d_j/v)\cos\theta_i$, v is the velocity of the signals, d_j is the distance between

sensor 1 and sensor j (j=1,...,N−V+1), θ_1 is any one of the estimated directions of the signal sources corresponding to the V said representative values, θ_i (i=2,...,N−V+1) are the estimated directions of the signal sources corresponding to the other said representative values of the V said representative values, and f is a frequency variable,

a procedure that calculates the inverse matrix $W(f)=H_{NBF}^{-1}(f)$ of delay matrix $H_{NBF}(f)$ as a NBF matrix W(f),

a procedure that generates a directional characteristics function FORMULA 54

$$F(f,\theta)=\sum_{k=1}^{N-V+1} W_{1k}(f)\exp(j2\pi f d_k \cos\theta / v)$$

where θ is a signal arrival direction variable, and the first row element of said NBF matrix W(f) is $W_{1k}(f)$,

and a procedure that uses said directional characteristics function F(f,θ) to generate said mask.

[7] A signal separation method according to Claim 1, wherein the procedure that uses said representative values to generate a mask for the purpose of extracting, from said frequency-domain signal values, mixed signal values comprising the signals emitted from V (2≤V≤M) signal sources includes:

a procedure that generates a function consisting of a single-peak function convolved with a binary mask, which is a function that takes a high level value for said relative values that are within a prescribed range including V said representative values and takes a low level value for said representative values that are not inside said prescribed range and where changes of the relative value are accompanied by discontinuous transitions

from said high level value to said low level value,

and a procedure that generates said mask as a function in which said relative values are substituted into said function consisting of a single-peak function convolved with a binary mask.

[8] A signal separation method according to Claim 1, wherein the procedure that uses said representative values to generate a mask for the purpose of extracting, from said frequency-domain signal values, mixed signal values comprising the signals emitted from V (2<=V<=M) signal sources is

a procedure that generates said mask as a single-peak function obtained by mapping the differences between a first odd function that takes a value of zero when said relative value is the lower limit value a_{min} in a prescribed range including V said representative values and a second odd function that takes a value of zero when said representative value is the upper limit value a_{max} in said prescribed range.

[9] A signal separation method according to Claim 2 or Claim 3, wherein

said mask is a function that transitions from said high level value to said low level value occur in a discontinuous fashion

[10] A signal separation method that separates and extracts signals under conditions where N ($N \geq 2$) signals are mixed together and observed with M sensors, comprising:

a procedure that transforms the observed signal values observed by said sensors into frequency-domain signal values,

a procedure that uses said frequency-domain signal values to calculate at each frequency the relative values of the observed values between said sensors (including mapping these relative values),

a procedure that clusters said relative values into N clusters,

a procedure that calculates a representative value for each of said clusters,

a procedure that generates a mask function that takes a high level value for said relative values that are within a prescribed range that includes one of the said representative values, and takes a low level value for said representative values that are not inside said prescribed range, wherein the transitions from said high level value to said low level value that accompany changes of said relative value occur in a continuous fashion,

and a procedure that multiplies said frequency-domain signal values by said mask to extract the signal emitted from one signal source.

[11] A signal separation method that separates and extracts signals under conditions where N ($N \geq 2$) signals are mixed together and observed with M sensors, comprising:

a procedure that transforms the observed signal values $x_1(t),\ldots,x_M(t)$ observed by said sensors into frequency-domain signal values $X_1(f,m),\ldots,X_M(f,m)$,

a procedure that clusters first vectors $X(f,m)=[X_1(f,m),\ldots,X_M(f,m)]$ comprising said frequency-domain signal values $X_1(f,m),\ldots,X_M(f,m)$ into N clusters $C_i(f)$ ($i=1,\ldots,N$) at each frequency f,

a procedure that calculates second vectors $a_i(f)$ to represent each said cluster $C_i(f)$,

a procedure that extracts V ($1 \leq V \leq M$) third vectors $a_p(f)$ ($p=1,\ldots,V$) from said second vectors $a_i(f)$,

a procedure that generates a mask M(f,m) represented by the formula

FORMULA 55

$$M(f,m)=\begin{cases}1 & \max_{a_p(f)\in G_k} D(X(f,m),a_p(f)) < \min_{a_q(f)\in G_k^c} D(X(f,m),a_q(f)) \\ 0 & \text{otherwise}\end{cases}$$

where G_k is the set of said third vectors $a_p(f)$, G_k^c is the complementary set of G_k, and $D(\alpha,\beta)$ is the Mahanalobis square distance between the vectors α and β,

and a procedure that extracts the signal values emitted from V of said signal sources by calculating the product of said mask $M(f,m)$ and said first vectors $X(f,m)$.

[12] A signal separation method that separates and extracts signals under conditions where N ($N\geq 2$) signals are mixed together and observed with M sensors, wherein

a procedure that transforms the observed signal values $x_1(t),\ldots,x_M(t)$ observed by said sensors into frequency-domain signal values $X_1(f,m),\ldots,X_M(f,m)$,

a procedure that clusters first vectors $X(f,m)=[X_1(f,m),\ldots,X_M(f,m)]$ comprising said frequency-domain signal values $X_1(f,m),\ldots,X_M(f,m)$ into N clusters $C_i(f)$ ($i=1,\ldots,N$) at each frequency f,

a procedure that calculates second vectors $a_i(f)$ to represent each said cluster $C_i(f)$,

a procedure that extracts V ($1\leq V\leq M$) third vectors $a_p(f)$ ($p=1,\ldots,V$) from said second vectors $a_i(f)$,

and a procedure that judges whether or not said first vectors $X(f,m)$ satisfy the relationship

FORMULA 56

$$\max_{a_p(f)\in G_k} D(X(f,m), a_p(f)) < \min_{a_q(f)\in G_k^c} D(X(f,m), a_q(f))$$

where G_k is the set of said third vectors $a_p(f)$, G_k^c is the complementary set of G_k, and $D(\alpha,\beta)$ is the Mahanalobis square distance between the vectors α and β, and, if so, extracts said first vectors X(f,m) as the signal values emitted from V of the said signal sources.

[13] A signal separation method according to Claim 11 or Claim 12, wherein said clustering procedure is performed after performing the calculation

FORMULA 57

$$\mathrm{sign}(X_j(f,m)) \leftarrow \begin{cases} X_j(f,m)/|X_j(f,m)| & (|X_j(f,m)| \neq 0) \\ 0 & (|X_j(f,m)| = 0) \end{cases}$$

and

$$X(f,m) \leftarrow \begin{cases} X(f,m)/\mathrm{sign}(X_j(f,m)) & (|X_j(f,m)| \neq 0) \\ X(f,m) & (|X_j(f,m)| = 0) \end{cases}$$

[14] A signal separation method according to Claim 13, wherein said clustering procedure is performed after performing the calculation

FORMULA 58

$$X(f,m) \leftarrow \begin{cases} X(f,m)/\|X(f,m)\| & (\|X(f,m)\| \neq 0) \\ X(f,m) & (\|X(f,m)\| = 0) \end{cases}$$

(where the notation $\|X(f,m)\|$ denotes the norm of X(f,m)).

After said formula

$$X(f,m) \leftarrow \begin{cases} X(f,m)/\operatorname{sign}(X_j(f,m)) & (|X_j(f,m)| \neq 0) \\ X(f,m) & (|X_j(f,m)| = 0) \end{cases}$$

[15] A signal separation method that separates and extracts signals under conditions where N ($N \geq 2$) signals are mixed together and observed with M sensors, comprising

a procedure that transforms the observed signal values $x_1(t),\ldots,x_M(t)$ observed by said sensors into frequency-domain signal values $X_1(f,m),\ldots,X_M(f,m)$,

a procedure that clusters first vectors $X(f,m)=[X_1(f,m),\ldots,X_M(f,m)]^T$ comprising said frequency-domain signal values $X_1(f,m),\ldots,X_M(f,m)$ into N clusters $C_i(f)$ $(i=1,\ldots,N)$ at each frequency f,

a procedure that calculates second vectors $a_i(f)$ to represent each said cluster $C_i(f)$,

a procedure that calculates an N-row × M-column separation matrix W(f,m) that is the Moore-Penrose pseudo-inverse matrix of an M-row × N-column matrix in which 0 or more of the N said second vectors $a_i(f)$ are substituted with zero vectors,

and a procedure that calculates a separated signal vector $Y(f,m)=[Y_1(f,m),\ldots,Y_N(f,m)]^T$ by performing the calculation $Y(f,m)=W(f,m)X(f,m)$.

[16] A signal separation method according to Claim 15, wherein:

the procedure that calculates said separation matrix W(f,m) is a procedure that selects min(M,N) said second vectors $a_i(f)$, generates a matrix A′(f,m) whose columns are the selected min(M,N) said second vectors $a_i(f)$ and max(N−M,0) zero vectors, and calculates said separation matrix W(f,m) as the Moore-Penrose pseudo-inverse matrix of said matrix A′(f,m).

[17] A signal separation method according to Claim 15, wherein:

the procedure used to calculate said separation matrix W(f,m) when N>M is a procedure that selects M said second vectors $a_i(f)$ in each discrete time interval m, generates a matrix A′(f,m) whose columns are the selected M said second vectors $a_i(f)$ and N–M zero vectors, and calculates said (time-dependent) separation matrix W(f,m) as the Moore-Penrose pseudo-inverse matrix of said matrix A′(f,m),

and the procedure used to calculate said separation matrix W(f,m) when N≤M is a procedure that calculates the Moore-Penrose pseudo-inverse matrix of a matrix comprising N said second vectors in each said cluster $C_i(f)$ to yield said (time-invariant) separation matrix W(f,m).

[18] A signal separation method according to Claim 15, wherein:

said clustering procedure is performed after performing the calculation

FORMULA 59

$$\mathrm{sign}(X_j(f,m)) \leftarrow \begin{cases} X_j(f,m)/|X_j(f,m)| & (|X_j(f,m)| \neq 0) \\ 0 & (|X_j(f,m)| = 0) \end{cases}$$

and

$$X(f,m) \leftarrow \begin{cases} X(f,m)/\mathrm{sign}(X_j(f,m)) & (|X_j(f,m)| \neq 0) \\ X(f,m) & (|X_j(f,m)| = 0) \end{cases}$$

[19] A signal separation method according to Claim 18, wherein:

said clustering procedure is performed after performing the calculation

FORMULA 60

$$X(f,m) \leftarrow \begin{cases} X(f,m)/\|X(f,m)\| & (\|X(f,m)\| \neq 0) \\ X(f,m) & (\|X(f,m)\| = 0) \end{cases}$$

(where the notation $\|X(f,m)\|$ denotes the norm of X(f,m)).

in addition to said formula

$$X(f,m) \leftarrow \begin{cases} X(f,m)/\operatorname{sign}(X_j(f,m)) & (|X_j(f,m)| \neq 0) \\ X(f,m) & (|X_j(f,m)| = 0) \end{cases}$$

[20] A signal separation method according to Claim 16, wherein said procedure that selects min(M,N) said second vectors $a_i(f)$ is a procedure that initializes fourth vectors e with said first vectors X(f,m), and then repeats a process min(M,N) times in which it selects said second vectors $a_{q(u)}(f)$ that maximize the absolute value of the dot product of $a_{q(u)}(f)/\|a_{q(u)}(f)\|$ and said fourth vectors, sets up a matrix $Q=[a_{q(1)}(f),\ldots,a_{q(k)}(f)]$ representing the subspace subtended by all said second vectors $a_{q(u)}(u=1,\ldots,k)$ selected so far, performs the calculation $P=Q(Q^H Q)^{-1}Q^H$, and updates the fourth vectors e with $e=X(f,m)-P\cdot X(f,m)$.

[21] A signal separation device that separates and extracts signals under conditions where N (N≥2) signals are mixed together and observed with M sensors, comprising:

a memory unit that stores the observed signal values observed by said sensors;

and a processor which is connected to said memory unit and performs processing whereby it;

transforms said observed signal values into frequency-domain signal values,

uses said frequency-domain signal values to calculate at each frequency the relative values of the observed values between said sensors (including mapping these relative values),

clusters said relative values into N clusters,

calculates a representative value for each of said clusters,

uses said representative values to generate a mask for the purpose of extracting, from said frequency-domain signal values, mixed signal values comprising the signals emitted from V ($2 \leq V \leq M$) signal sources,

uses said mask to extract said mixed signal values from said frequency-domain signal values, and

separates and extracts the values of V signals from said mixed signal values.

[22] A signal separation device that separates and extracts signals under conditions where N ($N \geq 2$) signals are mixed together and observed with M sensors, comprising:

a memory unit that stores the observed signal values observed by said sensors;

and a processor which is connected to said memory unit and performs processing whereby it;

transforms said observed signal values into frequency-domain signal values,

uses said frequency-domain signal values to calculate at each frequency the relative values of the observed values between said sensors (including mapping these relative values),

clusters said relative values into N clusters,

calculates a representative value for each of said clusters,

generates a mask, which is a function that takes a high level value for said relative values that are within a prescribed range that includes one said representative value, and takes a low level value for said representative values that are not inside said prescribed range, and where the transitions from said

high level value to said low level value that accompany changes of said relative value occur in a continuous fashion,

and extracts the values of a signal emitted from one signal source by multiplying said frequency-domain values by said mask.

[23] A signal separation device that separates and extracts signals under conditions where N ($N \geq 2$) signals are mixed together and observed with M sensors, comprising:

a memory unit that stores the observed signal values $x_1(t),...,x_M(t)$ observed by said sensors;

and a processor which is connected to said memory unit and performs processing whereby it;

transforms said observed signal values $x_1(t),...,x_M(t)$ into frequency-domain signal values $X_1(f,m),...,X_M(f,m)$,

clusters first vectors $X(f,m)=[X_1(f,m),...,X_M(f,m)]$ comprising said frequency-domain signal values $X_1(f,m),...,X_M(f,m)$ into N clusters $C_i(f)$ ($i=1,...,N$) at each frequency f,

calculates second vectors $a_i(f)$ to represent each said cluster $C_i(f)$, and extracts V ($1 \leq V \leq M$) third vectors $a_p(f)$ ($p=1,...,V$) from said second vectors $a_i(f)$,

generates a mask $M(f,m)$ represented by the formula

FORMULA 61

$$M(f,m)=\begin{cases}1 & \max_{a_p(f)\in G_k} D(X(f,m),a_p(f)) < \min_{a_q(f)\in G_k^c} D(X(f,m),a_q(f)) \\ 0 & \text{otherwise}\end{cases}$$

where G_k is the set of said third vectors $a_p(f)$, G_k^c is the complementary set of G_k, and $D(\alpha,\beta)$ is the Mahanalobis square distance between the vectors α and β

and extracts the signal values emitted from V of the said signal sources by calculating the product of said mask $M(f,m)$ and said first vectors $X(f,m)$.

[24] A signal separation device that separates and extracts signals under conditions where N ($N \geq 2$) signals are mixed together and observed with M sensors, comprising:

a memory unit that stores the observed signal values $x_1(t),\ldots,x_M(t)$ observed by said sensors;

and a processor which is connected to said memory unit and performs processing whereby it;

transforms said observed signal values $x_1(t),\ldots,x_M(t)$ into frequency-domain signal values $X_1(f,m),\ldots,X_M(f,m)$,

clusters first vectors $X(f,m)=[X_1(f,m),\ldots,X_M(f,m)]$ comprising said frequency-domain signal values $X_1(f,m),\ldots,X_M(f,m)$ into N clusters $C_i(f)$ ($i=1,\ldots,N$) at each frequency f,

calculates second vectors $a_i(f)$ to represent each said cluster $C_i(f)$,

extracts V ($1 \leq V \leq M$) third vectors $a_p(f)$ ($p=1,\ldots,V$) from said second vectors $a_i(f)$,

judges whether or not said first vectors satisfy the relationship

FORMULA 62

$$\max_{a_p(f)\in G_k} D(X(f,m),a_p(f)) < \min_{a_q(f)\in G_k^c} D(X(f,m),a_q(f))$$

where G_k is the set of said third vectors $a_p(f)$, G_k^c is the complementary set of G_k, and $D(\alpha,\beta)$ is the Mahanalobis square distance between the vectors α and β, and, if so, extracts said first vectors $X(f,m)$ as the signal values emitted from V of the said signal sources.

[25] A signal separation device that separates and extracts signals under conditions where N ($N \geq 2$) signals are mixed together and observed with M sensors, comprising:

a memory unit that stores the observed signal values $x_1(t),\ldots,x_M(t)$ observed by said sensors;

and a processor which is connected to said memory unit and performs processing whereby it;

transforms said observed signal values $x_1(t),\ldots,x_M(t)$ into frequency-domain signal values $X_1(f,m),\ldots,X_M(f,m)$,

clusters first vectors $X(f,m)=[X_1(f,m),\ldots,X_M(f,m)]^T$ comprising said frequency-domain signal values $X_1(f,m),\ldots,X_M(f,m)$ into N clusters $C_i(f)$ ($i=1,\ldots,N$) at each frequency f,

calculates second vectors $a_i(f)$ to represent each said cluster $C_i(f)$,

calculates an N-row × M-column separation matrix $W(f,m)$ that is the Moore-Penrose pseudo-inverse matrix of an M-row × N-column matrix in which 0 or more of the N said second vectors $a_i(f)$ are substituted with zero vectors,

and calculates a separated signal vector $Y(f,m)=[Y_1(f,m),\ldots,Y_N(f,m)]^T$ by performing the calculation $Y(f,m)=W(f,m)X(f,m)$.

[26] A signal separation program that causes a computer to perform:

a procedure that transforms observed signal values, which are mixtures of N ($N \geq 2$) signals observed with M sensors, into frequency-domain values,

a procedure that uses said frequency-domain signal values to calculate at each frequency the relative values of the observed values between said sensors (including mapping these relative values),

a procedure that clusters said relative values into N clusters,

a procedure that calculates a representative value for each of said clusters,

a procedure that uses said representative values to generate a mask for the purpose of extracting, from said frequency-domain signal values, mixed signal values comprising the signals emitted from V ($2 \leq V \leq M$) signal sources,

a procedure that uses said mask to extract said mixed signal values from said frequency-domain signal values, and

a procedure that separates and extracts the values of V signals from said mixed signal values.

[27] A signal separation program that causes a computer to perform:

a procedure that transforms observed signal values, which are mixtures of N ($N \geq 2$) signals observed with M sensors, into frequency-domain values,

a procedure that uses said frequency-domain signal values to calculate at each frequency the relative values of the observed values between said sensors (including mapping these relative values),

a procedure that clusters said relative values into N clusters,

a procedure that calculates a representative value for each of said clusters,

a procedure that generates a mask, which is a function that takes a high level value for said relative values that are within a prescribed range that includes one of said representative values, and takes a low level value for said representative values that are not inside said prescribed range, wherein the transitions from said high level value to said low level value that accompany changes of said relative value occur in a continuous fashion,

and a procedure that extracts the signal values emitted from one signal source by multiplying said frequency-domain signal values by said mask.

[28] A signal separation program that causes a computer to perform:

a procedure that transforms observed signal values $x_1(t),\ldots,x_M(t)$, which are mixtures of N ($N\geq 2$) signals observed by M sensors, into frequency-domain signal values $X_1(f,m),\ldots,X_M(f,m)$,

a procedure that clusters first vectors $X(f,m)=[X_1(f,m),\ldots,X_M(f,m)]$ comprising said frequency-domain signal values $X_1(f,m),\ldots,X_M(f,m)$ into N clusters $C_i(f)$ ($i=1,\ldots,N$) at each frequency f,

a procedure that calculates second vectors $a_i(f)$ to represent each said cluster $C_i(f)$,

a procedure that extracts V ($1\leq V\leq M$) third vectors $a_p(f)$ ($p=1,\ldots,V$) from said second vectors $a_i(f)$,

a procedure that generates a mask M(f,m) represented by the formula

FORMULA 63

$$M(f,m)=\begin{cases}1 & \max_{a_p(f)\in G_k} D(X(f,m),a_p(f)) < \min_{a_q(f)\in G_k^c} D(X(f,m),a_q(f))\\ 0 & \text{otherwise}\end{cases}$$

where G_k is the set of said third vectors $a_p(f)$, G_k^c is the complementary set of G_k, and $D(\alpha,\beta)$ is the Mahanalobis square distance between the vectors α and β,

and a procedure that extracts the signal values emitted from V of said signal sources by calculating the product of said mask M(f,m) and said first vectors X(f,m).

[29] A signal separation program that causes a computer to perform:

a procedure that transforms observed signal values $x_1(t),\ldots,x_M(t)$, which are mixtures of N ($N\geq 2$) signals observed by M sensors, into frequency-domain signal values $X_1(f,m),\ldots,X_M(f,m)$,

a procedure that clusters first vectors $X(f,m)=[X_1(f,m),\ldots,X_M(f,m)]$

comprising said frequency-domain signal values $X_1(f,m),\ldots,X_M(f,m)$ into N clusters $C_i(f)$ ($i=1,\ldots,N$) at each frequency f,

a procedure that calculates second vectors $a_i(f)$ to represent each said cluster $C_i(f)$,

a procedure that extracts V ($1 \leq V \leq M$) third vectors $a_p(f)$ ($p=1,\ldots,V$) from said second vectors $a_i(f)$,

and a procedure that judges whether or not said first vectors X(f,m) satisfy the relationship

FORMULA 64

$$\max_{a_p(f)\in G_k} D(X(f,m),a_p(f)) < \min_{a_q(f)\in G_k^c} D(X(f,m),a_q(f))$$

where G_k is the set of said third vectors $a_p(f)$, $G_k{}^c$ is the complementary set of G_k, and $D(\alpha,\beta)$ is the Mahanalobis square distance between the vectors α and β, and, if so, extracts said first vectors X(f,m) as the signal values emitted from V of the said signal sources.

[30] A signal separation program that causes a computer to perform:

a procedure that transforms observed signal values $x_1(t),\ldots,x_M(t)$, which are mixtures of N ($N \geq 2$) signals observed by M sensors, into frequency-domain signal values $X_1(f,m),\ldots,X_M(f,m)$,

a procedure that clusters first vectors $X(f,m)=[X_1(f,m),\ldots,X_M(f,m)]^T$ comprising said frequency-domain signal values $X_1(f,m),\ldots,X_M(f,m)$ into N clusters $C_i(f)$ ($i=1,\ldots,N$) at each frequency f,

a procedure that calculates second vectors $a_i(f)$ to represent each said cluster $C_i(f)$,

a procedure that calculates an N-row × M-column separation matrix W(f,m) that is the Moore-Penrose pseudo-inverse matrix of an M-row × N-

column matrix in which 0 or more of the N said second vectors $a_i(f)$ are substituted with zero vectors,

and a procedure that calculates a separated signal vector $Y(f,m)=[Y_1(f,m),\ldots,Y_N(f,m)]^T$ by performing the calculation $Y(f,m)=W(f,m)X(f,m)$.

[31] A computer-readable recording medium that stores a signal separation program according to any one of Claims 26 through 30.